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SECTION OF GEOLOGY AND MINERALOGY

APRIL 1, 1940

DOCTOR WALTER H. BUCHER, University of Cincinnati, Cincinnati, Ohio: *The Geology of the Cody Region.*

The geology of the Cody region comprises three major elements: (a) the broad, asymmetrical uplifts that surround the Bighorn Basin on three sides; (b) the scattered thrust masses of which Heart Mountain is the best known; and (c) the products of vulcanism of the Absaroka Mountains and the Yellowstone Park region. The chief purpose of the lecture was to bring out clearly the incongruous character of the thrust masses in the general regional setting.

1. The Beartooth Mountains illustrate the structural character of the uplifts. In the Beartooth Mountains, the Pre-Cambrian basement lies exposed for a distance of some 80 miles along the northwest-trending axis of the uplift, apparently forming a single unit. But throughout its whole width, from its northeastern foothills to the region around Gardiner in the southwest, the northern half of the uplift (including the Snowy Mountains) is dominated by movement from the northwest to the southeast, all secondary structures, such as folds and thrust-planes being overturned toward the southwest.

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The southeastern half of the Beartooth Mountains, on the other hand, from the Stillwater River to the plunging southern end of the uplift at Clark Fork Canyon, has been moved northeastward, the long dip-slope of the range sloping gently toward the southwest, while the front lies overthrust toward the northeast on to the Paleocene rocks of the foreland, individual units having been pushed forward differentially along tear faults.

Southeast of the Beartooth Mountains, in the direction toward Cody, the Paleozoic rocks emerge again from beneath the Tertiary cover to form two large anticlines, namely Pat O'Hara and Rattlesnake Mountains. The structure of both indicates movement in the opposite sense from that of the adjoining part of the Beartooth Mountains, the Rattlesnake Mountain fold especially being steeply upturned toward the southwest.

The same reversal of asymmetry along the axis of an uplift is exhibited on an even larger scale by the Bighorn Mountains. Here a northern and a southern portion were moved southwestward, while the central part was overthrust eastward between the latitudes of Sheridan and Buffalo, Wyoming.

In these, as in such minor uplifts as the Pryor and Owl Creek Mountains, the direction of overthrusting was clearly determined by local conditions (the Owl Creek Mountains are overthrust southward toward the deep Wind River basin). The asymmetries of the minor folds which line the borders of the Bighorn Basin, agree with those of the adjoining parts of the major uplifts. The whole structure is utterly different from that which characterizes the foreland of every major thrust belt known to the writer. It is the more surprising, therefore, to find in the Cody region isolated thrust masses which have been interpreted as the last erosion remnants of a huge thrust sheet which, if it actually existed, must have been one of the greatest of the continent.

2. The thrust masses consist of thick-bedded Paleozoic

ERRATUM

An error occurred in numbering the pages for the May, 1940, issue of the TRANSACTIONS, Ser. II, Vol. 2, No. 7. The first page of this number should have been 167, instead of 165, as printed. All page numbers in this issue should be correspondingly advanced, ending with p. 190, which becomes p. 192. No. 8, June, 1940, begins with p. 193.

rocks (Bighorn dolomite, Devonian limestones and shales, and Madison limestone) which have come to lie on Cretaceous and Tertiary rocks. Six such masses have been known since L. C. Dake and D. F. Hewett first recognized their nature. They seem to lie in two belts—an outer semicircular one, including Heart Mountain, McCulloch Peaks, and the small mass at the north end of Carter Mountain; and an inner one, comprising the mass near Bald Ridge, Logan Mountain, and Sheep Mountain, the largest of all. (See map in W. H. Bucher, W. T. Thom, Jr., and R. T. Chamberlin, "Geologic Problems of the Beartooth-Bighorn Region," *Bull. G. S. A.*, 1934, 45, opp. p. 167).

To the orthodox geologist it is a foregone conclusion that such widely scattered limestone masses are erosion remnants of a once continuous thrust-sheet. The speaker thought so himself at first. The detailed description of the observations that have caused him to reject that view will be given in the report that is in preparation. A few will be mentioned briefly:

a. The dimensions of the supposed original thrust sheet must have been at least of the order of 40 by 40 miles. Since the so-called erosion remnants consist only of Paleozoic limestones, the thrust sheet must have been formed by "peeling-off" the beds above the Cambrian. Such a process on such a scale is entirely out of harmony with the regional structural pattern.

b. If the thrust sheet had been formed in that manner, minor thrust faulting and imbrication should be a conspicuous feature of the internal structure of the preserved portions. None could be found. Instead, "normal" faulting and corresponding jointing dominate their structure.

c. The outermost, completely shattered fragments have escaped destruction by weathering, while over 99 per cent of the supposed thrust sheet, especially the portions that lay nearer the origin, have vanished completely.

d. The amount of weathering and erosion that had to be

accomplished to remove almost all of the supposed thrust sheet is entirely out of proportion to the available time.

e. The minor structures, which are exposed beneath the surface on which the thrust masses rest, are arranged with reference to a center (near Trout Peak), which serves equally well as the center of the semicircle into which the thrust masses may be grouped.

3. The time at which the thrust blocks reached their present position constitutes one of the most important questions connected with this problem. Here, also, our views are undergoing a change, but time did not permit a discussion of the stratigraphic and structural detail necessary for a satisfactory answer. One thing is obvious, namely, the thrusting took place before the beginning of the violent volcanic activity, which produced the extraordinarily coarse breccias that form the lower cliffs along South and North Forks of Shoshone River.

If the thrust masses are not erosion remnants of a once continuous thrust sheet, they are the product of a form of deformation, the nature of which is not understood as yet. Two regions are known to the speaker in which strong deformation was produced radially outward from a center—the belt of faulting that surrounds the Bearpaw Mountains in Montana, and the faulting and thrusting in and around the Ries basin in southern Germany.

SECTION OF BIOLOGY

April 8, 1940

Doctor Grace E. Pickford, Bingham Oceanographic Laboratory, Yale University and Albertus Magnus College, New Haven, Conn.: *The Vampyromorpha,* Living-Fossil Cephalopoda. (This lecture was illustrated by lantern slides.)

The name *Vampyroteuthis infernalis* was given by Chun to three specimens of a little black cephalopod which were captured by the "Valdivia" Expedition in the great depths of the Atlantic Ocean. Water color drawings were made by Rübsamen, the artist of the expedition. One of these, a side view, was published by Chun in 1903 in his book "Aus den Tiefen des Weltmeeres." It showed a black octopus-like creature with extensive development of the web and complete dorsal union of head and mantle. Near the apex of the body were *two* pairs of paddle-shaped fins. The arms bore pairs of cirri alternating with the suckers. Other cirrate-armed, fin-bearing Octopoda were already known and the Vampyroteuthidæ were unhesitatingly placed with them by earlier investigators of the group.

In later editions of his popular book and in the final description of the species as prepared by Thiele in 1915, after Chun's death, one of the two pairs of fins was deleted from Rübsamen's figure. The originals are still in the Zoological Museum of the University of Berlin, and one can see where the posterior fin was erased from the drawing.

Although the "little black octopus" is always rare, and usually badly rubbed and in poor condition when captured, there have been few deep sea expeditions which have not brought back at least one or two specimens. The largest numbers have been taken by the "Dana" Expeditions and, in all, there are now about seventy-five known specimens available for study, although a half of these—mostly those

captured by the 1928–30 "Dana" Expedition—have not been reported on as yet. Those captured by the 1920–21 "Dana" Expedition were investigated by Joubin (Final report: 1937).

Joubin was the first to notice that both two- and four-finned specimens existed and, as he rightly suggested, it turned out subsequently that Rübsamen's original figure was correct and that the type of *Vampyroteuthis infernalis* is actually provided with two pairs of fins. Various other supposedly significant taxonomic differences were recognized and, in 1938, there were as many as eleven species on record. Robson, in his "Monograph of the Recent Cephalopoda, Part II" (1932) (to which the student is referred for a comprehensive bibliography of the group), admitted eight genera, of which seven were monotypic.

As a matter of fact, in spite of Robson's attempt at clarification, the taxonomy of the vampyromorphs has been in a state of complete confusion. One author's criterion of description differed so greatly from another's that a comparison of species was often impracticable. Fortunately, it has recently been possible to make a re-examination of all named specimens. The results are as satisfactory as they were unexpected since it is now almost certain that only a single species exists. Many characters to which importance had been attached proved to be the result of poor preservation or incomplete observation, while others were directly related to the age of the animal. It can be shown that very young larvæ have a single pair of posterior or larval fins; that later these are resorbed and replaced by a more anterior pair of adult fins; but that larvæ of intermediate size may have both larval and adult fins, hence the four-finned specimens represented by the type itself. Only one species, *Lætmoteuthis lugubris* (Berry), was found to be incorrectly placed among the Vampyromorpha. This animal is actually a very damaged Eledoninid.

As the number of described specimens increased, it became evident that the Vampyroteuthidæ were not as closely related

to the other finned, cirrate-armed Octopoda as had been originally supposed. Several changes of classification were proposed but the most recent and most far-reaching was that of Robson, who raised the two groups to the rank of separate suborders of the Octopoda, the Vampyromorpha and Cirromorpha respectively. Although they show some superficial resemblances, Robson found that the vampyromorphs differed from the cirromorphs in several important respects. Among other things the vampyromorphs have a pair of retractile tentacles or filaments which can be completely withdrawn into pockets in the dorso-lateral sectors of the web. These filaments were supposed to be absent in the type of *Vampyroteuthis infernalis,* but as they were generally found to be present in other members of the group they came to be regarded as characteristic of it. As a matter of fact, this supposition was fully justified since a recent examination of the types has shown that they also are provided with retractile filaments (Pickford, 1939 *b*).

The internal anatomy of the Cirromorpha became generally rather well known through the work of several investigators, notably that of Meyer and, later, of Ebersbach. Although highly specialized, and in some ways rather primitive, there does not seem to be any reason to doubt that these forms are correctly placed with the Octopoda. On the other hand, the internal anatomy of the Vampyromorpha remained virtually unknown, except for a few scattered observations by Joubin and Robson's more careful study of the badly mutilated type of "*Melanoteuthis beebei.*" Yet such little information as was accumulated suggested that major problems of cephalopod classification were at stake. In particular, what was the nature of the retractile filaments? Both Robson and Joubin suspected that they represented modified arms, yet neither quite dared to insist that the Vampyroteuthidæ were other than rather primitive Octopoda.

Some salient features in the internal anatomy of an immature female belonging to the collections of the Bingham

Oceanographic Laboratory will now be described. The author has been working on this problem for about three years and preliminary reports have been presented at meetings both in this country and in England (Pickford, 1936, 1938). However, new facts come to light as the investigation proceeds, and the account which will now be given includes certain important and hitherto unreported observations.

The body of the animal, like that of so many deep sea forms, has a gelatinous consistency. Histological investigations show that the skin is covered by a thin pavement epithelium and that the underlying tissues are well supplied with branching and anastomosing blood vessels. Since the gills are rather small for the size of the animal it seems probable that their function may be supplemented by cutaneous respiration.

The general color of the animal is black, except for the oral face of the arms and web, which is of a reddish brown. Suckers, tips of cirri, funnel and mantle interior, etc., are tinged with crimson. Microscopic study shows that whereas the crimson pigment is situated in the epithelial cells of the epidermis, the black and brown pigment granules are found in chromatophores. The chromatophores differ greatly from the highly specialized pigmentary effector organs of other dibranchiate cephalopods. No muscles are attached to the cells and the pigment granules are spread out in a single layer or strung along thin protoplasmic strands. There is no evidence as to whether color change is possible but, if it takes place, it could only be slowly through the migration of granules. Luminous organs of three types are present in all well preserved specimens but, since their appearance is well known, they need not be further described at the present time.

The subcutaneous connective tissues contain branching mesenchyme cells, leucocytes, smooth muscle cells, spirally twisted fiber cells, whose fibrous portion gives the staining reactions of collagen, and, most remarkable of all, large, swollen, ovoid cells which seem to float freely in the matrix

and appear to be chiefly responsible for the gelatinous nature of this tissue.

The body musculature is not strongly developed but can, to a great extent, be compared with the musculature of other dibranchiates. Many of the muscles, although not powerful, are evidently capable of rapid "voluntary" contraction, since they are composed of transversely striated fibers. This is true of the mantle muscle, of the funnel retractor muscles, and of the fin muscles. It is doubtful whether typical cross-striated muscle occurs elsewhere among the Cephalopoda, but in the vampyromorphs it is characteristic, since, in suitable preparations, both Hensen's line and Krause's membrane may be recognized.

The internal skeleton is very weakly developed, but one can recognize a distinct U-shaped nuchal cartilage and a delicate capsule enclosing the brain and giving support by projecting trabeculæ to muscles of the head and eyes. The histology of the cartilage has yet to be investigated, but, under high power of the binocular, it appears parenchymatous.

The gladius, on the other hand, is remarkably well developed and greatly resembles that of certain Mesozoic teuthoideans from the lithographic shales. Naef, in his book "Die fossilen Tintenfische" and elsewhere (1921, 1922), has given an interpretation of the structure of these shells and his terminology must be applied to elucidate that of the vampyromorph gladius (See diagram in Pickford, 1939 *a*).

The anterior part of the shell sac is fully exposed when the skin is removed from the dorsal surface of the body. It extends forwards to the back of the neck and is about a third the width of the body in this region. Both shell and shell sac are almost completely transparent and one looks through them, as through a window, into the interior of the body. Posteriorly, the shell sac is overlain by a thin sheet of interlacing muscles which unite the two fin bases. When these have been cut one can trace the underlying shell sac back to

the apex of the body where it bends ventrally, covering the peculiar apical organ, which will be described later.

Upon removal from the shell sac, the gladius is found to be a delicate, semi-transparent, horny structure. It is completely uncalcified. Posteriorly, there is a cup-shaped, unchambered conus which widens out on either side to form a broad conus-vane. The conus-vane is, in turn, confluent with the equally broad lateral plate and the line of junction between the two, the outer asymptotic line of Naef, is considerably reinforced by a thickened ridge on the under surface of the shell. A broad, anteriorly blunt pro-ostracum projects forwards. This part of the shell is excessively thin and very easily damaged.

The fins rest directly on the shell sac whose wall is thickened to form what appear to be cartilaginous supports. In other living dibranchiates, the fin cartilages, although probably derived developmentally from the shell sac, are completely separated from it in the adult animal. The condition which appears to exist in the Vampyromorpha was postulated by Naef as that which must have prevailed among the ancestral Prototeuthoidea. Brunnmüller (1929) has described the histology of what she believed to be the fin cartilage of *Vampyroteuthis infernalis,* but a re-investigation has shown that the part which she removed for sectioning was actually the rudiment of the anterior fin of a young larva with well developed, posterior fins.

One of the characters which led the early investigators to place the Vampyromorpha with the Octopoda was the dorsal continuity of head and mantle. Dissection reveals that this is not a secondary fusion of the dorsal mantle margin with the back of the head, as in the Octopoda, or, among the Decapoda, in *Sepiola.* There is no dorsal mantle communication as there is in these forms where one can pass a probe dorsally above the level of the gills from one side of the mantle chamber to the other. In some of the Cirromorpha there is evidence that such a communication has become al-

most completely obliterated, but in the vampyromorphs the anatomical relationships of shell sac and musculature preclude the possibility of such an interpretation. The anterior margin of the shell sac is directly united with the underlying nuchal cartilage by a sheet of slender muscle fibers which pass downwards and slightly backwards from its under surface. The nuchal cartilage is, in turn, united with the cephalic cartilage by the dorsal retractor muscles of the head. This condition appeared at first to be primitive and was so reported in earlier abstracts. However, recent re-examination of a very young larva captured by the "Michael Sars" Expedition and now in the Bergens Museum has necessitated a re-consideration of the problem. In this specimen, the youngest ever investigated and perhaps only recently hatched from the egg, there is as yet no development of subcutaneous gelatinous tissue. The anterior margin of the shell sac projects forwards over the back of the head and, although there is no sliding groove or locking apparatus, the resemblance to a decapod is unmistakable. The adult vampyromorph condition may thus be interpreted as a degeneration not from the Octopoda but from a decapodan-like ancestor. This is not surprising since Naef has postulated that the decapod arrangement must have prevailed among the ancestral Prototeuthoidea.

The opening into the mantle chamber extends laterally on each side to the level of the eyes. The funnel is largely sunk in the gelatinous tissues of the head. It is provided with a triangular valve and a pair of swollen funnel glands. In some vampyromorphs there was supposed to be a rudimentary locking apparatus by which the mantle margin could be held to the funnel base, as in the Decapoda. Although there is no definite structure supported by cartilage, it appears that a suction cup can be formed by the powerful funnel retractor muscles. These muscles are cylindrical, the interior core of the cylinder being filled with gelatinous connective tissue. At the base of the funnel muscle, fibers from the outer side of

the cylinder bend at right angles and continue laterally outwards into the collaris muscle, while fibers from the inner side of the cylinder enter the funnel base. There is thus created, at the junction of the funnel retractor muscle with the funnel base, a cup-shaped depression overlying the soft interior core of the muscle column. This depression can be very conspicuous when the muscle is strongly contracted and it seems probable that it must have functioned as an adhesive cup during life. There is no corresponding knob or prominence on the opposing surface of the mantle.

On looking into the mantle chamber, one finds that there is no median pallial septum nor median pallial adductor muscle. Lateral pallial adductors are also absent. This constitutes another of the many differences between vampyromorphs and the Octopoda.

The vampyromorph gills have never been properly described. Robson (1932), on the basis of a drawing by Joubin, surmised that they might be quite free as in *Nautilus*. This is not the case. Each gill is suspended by a branchial septum in which lies an apparently perfectly typical branchial gland. The detailed structure of the gill is not that of an octopod. The primary lamellae, although relatively few in number as in octopods, are built on the decapodan plan. Very young animals may have as few as three or four primary lamellæ in each demibranch. The magnificent adult female of the Oceanographic Institut at Monaco has as many as fourteen. The part probably played by cutaneous respiration was mentioned previously.

The cœlom is a spacious cavity lined by a pinkish-red pavement epithelium. In it lie suspended the heart and the ovary. There is no constriction separating pericardium from gonocœle. Small cœlomic outpocketings cap the ends of the branchial heart appendages. Wide cœlomiducts open anteriorly into the kidney sacs and the oviducts leave the anterior part of the cœlom close beside the cœlomiducts to open at the gill bases. From the posterior end of the cœlom a very

slender canal leads backwards to the apex of the body where it opens into a peculiar apical cœlomic organ which is lodged within the cup-shaped conus of the shell. This canal is readily traced in dissections on account of the red color of the cœlomic epithelium. The apical cœlomic organ is suspended from the margins of the shell sac by slender muscles. There can be no doubt that the canal and sac represent the siphuncular cœlom of *Spirula* and *Nautilus* (Naef, 1913), which has persisted in the vampyromorphs in spite of the disappearance of a chambered phragmocone.

Vampyromorphs are provided with moderately well chitinized jaws and a radula of relatively simple tooth pattern, not unlike that of *Sepia*. Previous investigators have not studied the salivary glands and, since the buccal mass of the specimen now under examination remains to be dissected, nothing can be said in this connection at the present time. The œsophagus can be seen through the shell sac in all specimens which are sufficiently rubbed for this structure to be exposed. It generally shows a slight ventral dilation immediately before it perforates the muscular diaphragm and occasionally this dilation is markedly distended. Serial sections reveal no histological peculiarities by which the walls of this rudimentary crop could be distinguished from those of the more anterior parts of the œsophagus. The lining is a little more folded and evidently permits distention.

The stomach is strongly muscular and opens into a cæcum of rather simple type. The rectum is without anal valves and there is no ink sac. Joubin thought that he had found an ink sac in *Retroteuthis pacifica* but it is merely the heavily pigmented rectum which can be seen vaguely through the tissues when the mantle chamber is opened.

The liver is a compact gland and the pancreas is completely incorporated in its posterior end. This is one of the few strictly octopodan characters displayed by the Vampyromorpha. In Decapoda, the pancreas is a more diffuse gland which lies loosely around the hepatic ducts.

The heart of the Vampyromorpha is also strictly octopodan; since the genital artery arises slightly dorsally near the posterior margin of the ventricle. One of the most difficult parts of the dissection has been the investigation of the venous system. It is doubtful whether a complete account will be possible. The veins are excessively thin-walled and, as in Octopoda, frequently open out into spacious sinuses. The exact extent of the venous spaces is not at present clear. A sinus surrounding the brain communicates by a long slender vein on the dorsal surface of the œsophagus with another sinus which surrounds at least part of the stomach and cæcum. The Vampyromorpha probably resemble the Cirromorpha in that the venous system is transitional between the closed system of the Decapoda and the extensive development of venous sinuses in Octopoda proper.

As in the Decapoda, an inner arm vein ring surrounds the mouth and receives brachial and interbrachial veins from the oral face of the web. A part of the evidence that the retractile filaments represent modified arms is provided by the fact that they similarly return their blood to the arm vein ring by way of superficial vessels running on their oral surfaces. There are no brachial veins on the aboral surface of the arms and there is no external arm vein ring encircling the head in front of the eyes as one usually finds in the Octopoda.

In immature animals the kidney sacs lie on either side of the rectum and have no apparent communication with each other. The excretory openings have usually been overlooked while the female pores, situated further back at the angles of the gill bases, have been mistaken for the anus. The relation of cœlomiducts and oviducts to the cœlom has already been explained. The ovary is a large compact gland suspended freely in the cœlom (1) by a dorsal mesentery and (2) by a special muscle originating posteriorly from the under surface of the shell sac. Only two adult female vampyromorphs have ever been captured and although the external characters have been subjected to a preliminary examination (Pickford, 1939 *a*)

their internal anatomy remains to be investigated. In both specimens the oviducal openings are surrounded by a circular sucker-like glandular structure. There are no traces of nidimental glands but the kidney sacs are remarkably enlarged and appear to communicate with each other posteriorly. Rounded bodies resembling eggs could be observed floating freely within the kidney sacs. The possibility that these may function as a brood pouch cannot be overlooked.

Even half-grown immature females can be distinguished from males by the presence of a pre-ocular pit organ which, in adults, takes the form of an ovoid sac sunk beneath the skin and opening in the center of a depressed circular area of pinkish-red skin. The histological structure and function of this organ are unknown.

Many specimens, especially in the "Dana" collections, have proved to be half-grown males. A few of these approach maturity and at least one is fully developed. In any of these specimens one finds that the penis is situated on the left side and that the large spermatophore glands hang out freely into the body cavity. This condition, not known in other living dibranchiates, is evidently primitive and was predicted by Naef.

The vampyromorph brain differs from that of the Octopoda and more nearly resembles that of Decapoda in the lack of concentration of its component ganglia. The brachial nerves arise from a separate brachial ganglion but there is much dispute as to the place of origin of the filament nerves. On account of its potential importance this point was considered both by Joubin and by Robson. Joubin found that it arose along with the other brachial nerves from what he wrongly described as the "pedal ganglion." Robson studied an already badly macerated specimen and was able to dissect the filament nerve away from the brachial ganglion and follow it back towards the pedal ganglion. In spite of the condition of the specimen his observations can be partly confirmed (Pickford, 1939 *c*). Nevertheless, in the well preserved

Bingham Oceanographic specimen, the filament nerve arises in series, along with the other arm nerves, from the brachial ganglion. Possibly the tracts continue through the ganglion into the pedo-brachial commissure, and hence could be dissected out in a macerated specimen. The matter will be settled by further investigation.

The sense organs are well developed. The ear vesicle is large, in young larvae actually larger than the eyes. The eyes are with an open pupil as in the Oigopsida. Reports of specimens with pedunculate eyes result from the fact that the entire eye bulb is frequently seen protruding out of the pupil, no doubt due to violent contractions at the time of death. The eye stalk is encircled by a pinkish-yellow skin gland which seems to have been mistaken by Chun for the white body. A white body is absent. Olfactory papillæ are situated behind the eye on either side near the angle of the mantle opening.

In conclusion, the Vampyromorpha may be defined as a new order of dibranchiate Cephalopoda in which there are five pairs of arms, the second dorsal pair being modified to form retractile filaments; in which, on the unmodified arms, the suckers are arranged in a single row, each sucker alternating with a pair of cirri; in which there is a large, uncalcified and unchambered horny gladius provided with a broad, blunt pro-ostracum and extensive lateral plates confluent with the conus vanes; in which an apical pair of slender larval fins is replaced at metamorphosis by an adult pair of more anteriorly situated paddle-shaped fins; in which the fin supports are cartilaginous thickenings in the wall of the shell sac; in which the larva possesses a forwardly projecting dorsal mantle fold that does not articulate with the back of the head and which, in the adult, becomes completely obscured by the overgrowth of subcutaneous tissues so that the mantle is completely continuous dorsally with the back of the head; in which the gills resemble those of the Decapoda in structure but possess a greatly reduced number of primary gill lamellae; in which the genital artery arises separately from the postero-

dorsal region of the ventricle and in which the heart is wholly Octopodan in character, while the venous system shows a partial development of venous sinuses; in which the digestive system is relatively simple and unspecialized, the pancreas being incorporated in the compact liver as in the Octopoda and an ink sac being absent; in which there is a spacious and unrestricted cœlom surrounding the heart, gonad and branchial heart appendages and communicating by a slender canal with a rudimentary siphuncular cœlomic sac situated in the apex of the body; in which there are two oviducts in the female, but only a single left genital duct in the male; and in which the spermatophore glands of the male are not enclosed within a genital pocket. Habitat:—The great depths of all tropical oceans.

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SECTION OF ANTHROPOLOGY

APRIL 22, 1940

DOROTHY L. KEUR, Hunter College, New York, N. Y.: *New Light on Navaho Origins.* (This lecture was illustrated by the use of opaque projection apparatus.)

All are agreed that the Navahos are not indigenous to the area in which they were first observed by the Spaniards. Evidence given by the linguist and the ethnologist, documents of the earliest historians, and traditions of the Puebloans and Navahos themselves, all attest the non-southwestern origin of the latter. The problem of their origin may be tersely formulated as follows: Whence and when did they come, and by what route?

The linguist has pointed out that the great Athabaskan stock, to which the Navaho language belongs, has its historical center of gravity somewhere to the north. Athabaskan is spoken not only by the Navaho and Apache of the southwest, but also by several small tribes in northern California, such as the Hupa, Tolowa, and Kato; and by the Dene tribes of western Canada, including the upper and lower Yukon, and the Mackenzie River valleys. Sapir further links the Athabaskan stock to the Haida and Tlinget, to form the Na-Dene group. On the basis of the degree of dialectic diversity, he posits the historical center of gravity for Athabaskan in the north. The southern group, by contrast, is quite homogeneous.

The historical data are significant in considering the period after the Navahos had reached their southwestern home. Escalante and Dominguez, in 1776, were the first to map the location of the Navaho. They indicate a region north and west of Zuni as "Provincia de Nabajoo." Other historic documents tell of fortified mesas, the cultivation of maize in nearby fields, and the presence of flocks of sheep. They indicate, albeit sketchily, the multiplicity and intricacy of Navaho-Pueblo relations.

History and ethnology both give evidence that the Navahos probably obtained maize, sheep, the arts of weaving and silversmithing, and quite possibly of sand painting, from the Pueblos. The hogan is distinctive to the Navaho, and possibly the cooking pots or utility ware. This pottery seems un-southwestern in tradition.

The linguist, historian and ethnologist all turn to the archaeologist for further light in the solution of Navaho origins. This is a problem demanding the direct historic approach, starting from a known and documented horizon, and pushing back to prehistoric evidence. Until very recently, the interest in Navaho archaeology has manifested itself only in observation and survey. As early as 1912, Kidder noted three settlements in the upper San Juan Valley, New Mexico, which he suggested were probably of mixed Pueblo and Navaho origin. Each settlement contained small Pueblo units and associated hogan-like structures, both of which were completely surrounded by unbroken defense walls. Presumably they were historic in time, since a "hooded" fireplace, believed to be of Spanish origin, was present in one case, and the timbers appeared to have been cut with metal axes. They strongly suggest refuge sites. In 1916, Nelson observed comparable ruin sites in the Largo Canyon. Others were reported as occurring sporadically in Carriso and Burns Canyons, and in the Puerco drainage. Stallings and Hall recently made a survey in the Gobernador region and found hogan sites associated with round towers, presumably watch towers for defense. Malcolm, in 1937, made a survey of hogan sites in the Chaco Canyon area and reported 48 sites. Farmer, 1938, located 29 sites in the Largo and Blanco Canyons, several of which were associated with two-storied, round towers. Farmer carefully excavated two of the hogans.

Our work was undertaken in the summer of 1939 in Guadalupe Canyon, 75 miles northwest of Albuquerque, New Mexico. 95 hogan sites were excavated. 72 of these occurred atop Big Bead Mesa with many other types of structure in associa-

tion. There were sweat houses, lean-tos, caches, rock shelters, dance grounds and fortifications. Nothing distinctly Pueblo-loan in the architecture was present.

Hogans were of two types:—the forked stick and the stone circle. The former consisted of several (3–5) pinyon poles, forked at the upper end, set in the ground approximately equidistant on the circumference of the hogan floor, with forked tops interlocking; hence producing a conical framework. Other timbers were placed between to fill out the structure. The stone circle type consisted of a ring of rough boulders or a circular wall of rectangular sandstone blocks, more or less regularly coursed. Often natural outcrops or huge sandstone boulders were utilized as a section of the stone ring. It is not known exactly how such hogans were roofed, but a cribwork of small and light timbers seems a possible means. The hogans varied in diameter from 6 feet to 15 feet. After excavation, the bare hard packed floors often revealed only fireplaces. Their usual location was slightly off-center, toward the doorway. Other features occasionally present include deflectors of large stone slabs set on one side of the fireplace, mealing bins, caches, metates and manos, and a pair of small holes neatly lined with white sandstone, presumably to support loom posts.

Natural cavities, or recesses formed by overhanging sandstone ledges, were utilized as caches. In most cases, a stone wall had been constructed across the opening. Most caches were entirely empty, but one yielded over 500 corn cobs. The corn was of a variety indistinguishable from that used by the Pueblos.

Sweat houses could be recognized by tell-tale heaps of fire-reddened stones and the fireplace could usually be located from their position. The sweat houses were somewhat removed from the groups of hogans and one occurred at the foot of the main trail up the mesa. This suggests their use in purification rites and is in keeping with modern sweat-bath practises.

The two dance-grounds discovered appeared to be flat

cleared areas, roughly retangular in form, extending directly east of hogans, and lined by several fireplaces. The larger of the two measured approximately 20 by 30 feet. Ten fireplaces were located here, arranged in two rows. This would indicate the proper setting for the Navaho Night Chant.

Fortifications consisted of the crude piling of stones along natural promontories and of a spectacular great wall, erected across a narrow neck of Big Bead Mesa, cutting off a northeastern spur with 23 hogans from the remainder of the mesa. If the enemy succeeded in gaining access to the mesa top, a last stand could well be taken behind this great wall, 26 feet long and 12 feet high. On its northeast face, the wall has a setback, forming a ledge 5 feet above the ground, where guardsmen could have been stationed. Three peep holes, evenly spaced in the upper part of the wall, could have furnished them the necessary sights. At the head of the principal and only readily accessible trail up the mesa, stood a large grooved boulder, presumably another defense device. It seems plausible that the boulder, 4 feet in diameter and weighing several hundred pounds, had been encircled by a rope or thong set firmly in its groove, and thus was suspended from the top of the trail, so that it could have been sent crashing below on hostile visitors, by simply cutting the thong.

The chief means of subsistence of the inhabitants of Big Bead Mesa appears to have been maize and sheep. Bones of the latter were plentiful and also deer bones, indicating a considerable amount of hunting. Large parts of horse skeletons were excavated in the fill of the hogans. It is quite difficult, but possible, for a horse to ascend the mesa today.

Tools and implements were crude and simple. Stone work included such types as hammerstones, mauls, metates, manos, choppers, shaft straighteners, scrapers, knives and arrow heads. The latter varied considerably in form, but were no different from those described for the Pueblos. The materials out of which they had been manufactured, notably obsidian, chert and chalcedony, were conspicuous, since no source for

them was found in the vicinity. Bone work was very scarce. A few small beads occurred, a few awls and one piece of worked antler. One bone tube (swan) had been cut and notched at one end.

In addition to such ceremonial structures as the sweat-house and dance-ground mentioned above, evidence of ceremonial life was found in a small cache of sand-painting materials. Four colors were represented here. These were lumps of extremely soft and friable red and yellow sandstone, a piece of white chalky material, and large fragments of charcoal. In a deep recess under an overhanging ledge, were found two spruce poles, with side branches neatly trimmed, and bases pared to long slender points. These were regarded as very sacred by our informant. The presence of spruce was notable, since no spruce was observed now growing within a radius of 100 miles. Such pointed poles are said to be swallowed by some of the performers on the ninth night of the Mountain Chant.

The ceramics, as indicated by the sherds of both surface and fill, manifested an interesting dichotomy. There seems to be a basic distinction between cooking or utility ware, and slipped or/and painted Puebloid ware. Utility ware is characterized by round or conical bottoms, flaring rims, thin, gray to black paste, marked scoring, and frequent pitching. Infrequently, decoration is present in the form of appliqued fillets applied around the neck, and then stick marked or punctated. This general type of ware has a very widespread distribution, and, in general, might be called Woodland. Rather close analogies have been noted to the Dismal River sherds from Nebraska, and to Ute sherds found in Southern Colorado. At any rate, this ware seems un-southwestern in tradition, except for its appearance in the Gallina sites of the Chama region.

The Puebloid wares were of two types, an early "Anasazi" group, and a late, 17th to 19th century group. The former, consisting of Pueblo II to III black on white and corrugated

wares, were presumably intrusive, and might well have been pilfered from nearby Anasazi ruins. The latter type of Puebloid wares is significant in that it might furnish a clue to Navaho-Pueblo relations. The wares fall into four groups: (1) Navaho polychrome, classified as a Puebloid ware because of its obvious puebloid origin; (2) Ashiwi polychrome, of a Acoma-Laguma affiliation; (3) Puname polychrome, of a Zia-Santa Ana affiliation; and (4) Black-on-Red with Gobernador polychrome affinities. It is notable that in the case of (2) and (3), the affiliations appear to be with Keresan peoples. Such anomalies have been found, however, as a Puname polychrome bowl with a very Hopi-like, black-on-red design on the exterior; or a Puname polychrome olla, with a characteristic Jemez handle.

The Puebloid sherds fall within the 18th and early 19th centuries, according to Stallings. This is neatly confirmed by the dates obtained by Hall, through dendrochronology. These dates run from 1689 + x, and 1782 ± 1, to 1811 ± 20.

In conclusion, let us note the problems which remain quite unanswered, and which future archaeology may help to solve.

(1) At what time did the Navaho actually come into the southwest, and by what route? To answer this, we must seek earlier, and, if possible, "pure" Navaho sites, and possibly track down a trail of pot-sherds and house rings to the north.

(2) What area in the southwest did they first occupy?

(3) What was the extent and nature of Pueblo contact?

(4) How much of the present Navaho culture, if any, is of an Athabaskan base? Were they an earth-lodge dwelling, pottery-making, yet non-agricultural group, when they came?

Hence it appears that we have merely introduced the subject, by the first few probes back into the past, from the known historical and ethnological level.

NEW MEMBERS

Elected April, 1940

SUSTAINING MEMBER

Sullivan, Harry Stack, M.D., President, William Alanson White Psychiatric Foundation, Bethesda, Md.

ACTIVE MEMBERS

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